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THE RELATIVE FITNESS VALUE OF SPORTS PLAYED BY CANADIAN FORCES PERSONNEL

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THE RELATIVE FITNESS VALUE OF SPORTS

ABSTRACT

Canadian Forces (CF) personnel are encouraged to participate in organized sports as a means of achieving and maintaining a desirable level of physical fitness. This study was undertaken to determine whether CF sport participants were more physically fit than a reference CF population, and to determine which sports most effectively promote physical fitness. Five components of physical fitness, including aerobic power, strength, muscular endurance, flexibility, and an estimate of body fat, were measured with a battery of standard tests. The results indicated that the sport participants had higher aerobic power, were stronger, possessed greater muscular endurance, greater flexibility, and had less subcutaneous body fat than the reference CF population. According to the fitness of the competitors, the sports were ranked in the following descending order: (for males) volleyball, marathon running, hockey, broomball, badminton, softball, curling and bowling; (for females) volleyball, curling and softball. It was concluded that the CF sport competitors were, in general, more physically fit than the CF reference population and that volleyball players were the fittest of all the sport competitors tested.

INTRODUCTION

The importance of physical fitness to the Canadian Forces (CF) is reflected in Canadian Forces Administrative Order (CFAO) 50-1 where detailed regulations are promulgated for the promotion of physical fitness among CF personnel. The importance of participation in organized sport as one method of achieving this aim is recognized by the several sections in the CFAO allotted to this aspect. However, the relative contributions to physical fitness of the several authorized sports activities are not well defined. With one exception (1), the limited literature on this subject consists of subjective reports by coaches and sports administrators based on their experience with team and individual sports (2,3). No objective analysis based on measurements of recognized physical parameters on non-professional sports participants appears to have been undertaken. Within the CF, this type of information would be useful in decisions on the allocation of scarce resources.

This study was undertaken during 1979-80 to meet this requirement with respect to the CF population. Standard measurements of physical fitness (aerobic power, strength, muscular endurance and flexibility) were performed on 605 competitors who participated in the final CF championship events in the following sports:

Male participants - badminton
bowling
broomball
curling
hockey
marathon running
softball
volleyball

Female participants - curling
softball
volleyball

An estimate of body composition using skinfold thicknesses was also made on all competitors. For purposes of comparison, the same data were collected on a reference male population (CF POP) from a typical CF base. The resulting data were processed to produce a rank order of sports in terms of the measured physical fitness of the participants.

The results indicate that it is possible to rank order the fitness component of sports participation and that sport personnel (except bowlers) are more fit than the CF POP.

METHOD

The subjects for this study were the 453 male and the 152 female competitors who competed in the CF national sport championships held during 1979-80. The CF POP consisted of 164 males stationed at Canadian Forces Base Portage La Prairie during the spring of 1980. There were too few available at that time to constitute a similar female reference group. While not entirely representative of the CF, this group has many characteristics of personnel from several CF bases and is used in this report as a reference population. The subjects ranged in age from 17 to 55 years. The specific physical characteristics are shown in Table 1.

Table 1. Physical Characteristics of Subjects

		Mean ± SD		
Male Population	(n)	Age (yrs)	Height (cm)	Weight (kg)
Badminton	67	38 ± 8	174 ± 6	76 ± 8
Bowling	40	39 ± 6	173 ± 6	78 ± 11
Broomball	85	29 ± 6	175 ± 7	76 ± 9
Curling	13	33 ± 6	174 ± 4	74 ± 9
Hockey	101	27 ± 5	174 ± 6	79 ± 9
Marathon	22	35 ± 8	174 ± 6	68 ± 5
Softball	75	30 ± 6	176 ± 6	79 ± 10
Volleyball	50	28 ± 6	182 ± 6	78 ± 8
Mean	453	31 ± 8	174 ± 6	77 ± 9
CF POP	164	37 ± 7	176 ± 7	79 ± 11
Female Population				
Curling	20	32 ± 2	167 ± 7	66 ± 8
Softball	74	24 ± 4	165 ± 6	65 ± 10
Volleyball	58	23 ± 3	167 ± 9	64 ± 9

A battery of tests, selected from those suggested by the Canadian Association for Health, Physical Education and Recreation (4) and by the International Committee for the Standardization of Physical Fitness Tests (5), was used to determine the physical fitness of all subjects.

This test battery was as follows:

1) Aerobic power was determined from a step test.

2) Upper body strength was determined from right and left hand grip strength, using a hand dynamometer. Lower body strength was measured using a vertical jump test.

3) Muscular endurance was evaluated from timed situps and pushups.

4) Flexibility was determined using both a sit and reach test and a back extension test.

5) Leanness, or the degree of fatness, was evaluated from skinfold thickness, measured with skinfold calipers at three sites.

Detailed protocols for these procedures are shown in Appendix A.

The competitors completed all the tests two or three days prior to their scheduled competition. The aerobic power evaluation was always conducted first while the remaining tests were conducted as the competitors were available and not in any specific order.

Statistical Treatment of Data

Two statistical treatments were applied to the data. In the first instance, the measured data for each component of fitness were plotted against age for each of the two male populations (Figures 1-9). The resulting plots were compared using an analysis of covariance.

In the second instance a rank order for each of the eight sports plus the CF POP was constructed as follows:

(a) using standard regression techniques, the data were adjusted to age 30 years, the approximate mean age (31 ± 8) of the subject population;

(b) the age-adjusted data from each fitness component were rank ordered (1-9) for each sport. Where more than one test was used to assess a fitness component (strength = hand grip + vertical jump) a combined ranking was produced;

(c) a class frequency table was constructed (Table 9) using these rank orders from each sport;

(d) the class frequency table was used to produce a final rank order for each sport plus the CF POP(Figure 10); and,

(e) the same techniques were applied to the female data (Figure 11).

The class frequency Tables 9 and 10 were subjected to a one way rank analysis of variance (6) to determine the significance of the final ranking.

Significance was set at $p < 0.05$ for all statistical treatments.

RESULTS

The data from this study have been organized to achieve two purposes: firstly, a comparison of the CF POP male population with the male sports participants as a group and secondly, to construct a rank order for the sports using the measured physical fitness values. Figures 1 - 8 display the comparisons between the two populations for each of eight tests performed on the personnel. Each population is treated as a whole as represented by the appropriate line in Figures 1 - 8. Significant differences between the lines are indicated. These data are presented to show the relative decline with age for each test performance for each population to highlight both the differences at each age and the general rate of decline.

It is apparent that the sport population generally displays higher values for each test at all ages with a few exceptions. These occur at either end of the age span and are probably artifacts produced by the small numbers in these age categories. Taking the populations as a whole (all ages combined), a significant difference exists for aerobic power, right and left grip strength, vertical jump, situp, pushup and forward flexion. Only back extension fails to display a significant difference between the two groups (Figure 8) for all ages.

The sum of the three skinfolds is also significantly different for the two groups with the sport population being less fat (Figure 9). The characteristic increase with age until about 40 years is evident for both groups (7). The decline after age 45 is unexpected and may also be an artifact of the small numbers involved at these ages.

The data were then reorganized to remove the age effect by statistical adjustment to age 30 years, the approximate mean age of the sports population. This allowed for intersport comparisons of total physical fitness ranking and a relative comparison of each measured component of fitness. Each sport group was ranked according to the measured value in each test and arranged so that the lowest value was given a rank of 1 and the highest given a rank of 9 (Tables 2 and 7, Appendix B). Each sport group was then characterized in Fig. 10 by adding the rankings of all five tests to produce an overall sport ranking. For instance, bowling with component rankings of 1, 1, 1, 2 and 4 (see class frequency table 9, Appendix B), is accorded an overall value of 9 while volleyball with component rankings of 6, 8, 8.5, 9 and 9 is accorded an overall value of 40.5, the highest value. All remaining sports are ranked between these extremes as shown in Figure 10. Within this context the reference population is accorded an overall value of 11.5 with a final ranking lower than all sports except bowling.

It is important to realize that this is a statistical manipulation and the height of the bars in Figure 10 does not indicate the magnitude of the intersport difference. Using aerobic power as an example, bowlers are lowest (rank 1) with a mean value of 34.1 ml/kg.min, volleyball players with a value of 42.5 ml/kg.min are ranked 6 and marathon runners are highest (rank 9) at 57.4 ml/kg.min. The difference in aerobic power between bowlers and marathon runners is of the order 1:1.75 while the rankings are 1:9 as shown in Figure 10.

Figure 11 was constructed in the same manner for the three sports in which female participants were studied. Again, volleyball is accorded the highest overall ranking.

DISCUSSION

Before the results of this study can be put into proper perspective, a few observations on the nature of the participants in this study are in order. The 605 personnel on whom measurements were taken were the surviving competitors who reached the championship finals in each of the sports and as such may not represent the remainder of the personnel who are routinely active in a particular sport. A selection, presumably based on skill, will have occurred during the eliminations and the effect of physical fitness on this selection is not easy to ascertain. On the other hand, the same selection may have occurred for all sports under study and comparison either between sports or between sports participants and non-participants may be the only way to assess the influence of physical fitness.

Another factor requiring comment is the relative contribution of each of the five identified components of physical fitness to a partic-

ular sport. If we accept the idea that participants will tend to pursue those activities at which they can excel (8,9,10), it is clear that marathon runners are not likely to possess a high level of upper body strength. Development of this attribute not only adds nothing to running ability but will probably detract from performance. Similarly, it is evident that successful hockey players will require upper body development as well as powerful legs giving them a greater overall strength. For the purposes of this report each measured characteristic was given equal weighting in the analysis from which the rank order was produced. If aerobic power, for instance, is considered to be of greater value than, say, flexibility, in determining an overall value for physical fitness, the reader must apply his own criteria to the rankings shown in the appendices.

Since the rationale for this study was to attempt to determine the effect of regular sports participation on physical fitness, the degree to which these personnel meet the requirements of CFAO 50-1 provides an additional criterion. Performance standards are specified for aerobic power and muscular endurance (situps, pushups) and can be used to assess the influence of sports participation on levels of physical fitness. Inspection of the data in Appendix B, Table 2, shows that the male sports of broomball, hockey, marathon running and volleyball have mean values for VO_2max which meet or exceed the requirement for level 4 (Good). For female sports, only curling fails to meet this requirement. For muscular endurance (Table 4), the results indicate that all male sports meet the requirement for situps while bowling, curling and softball fail to meet the pushup requirement. As a matter of comparison, the mean VO_2max for the CF POP is marginally below the requirement while the mean for muscular endurance exceeds the requirement.

Since no CF standards have been promulgated for the remaining components of fitness measured in this study (flexibility, strength and body composition), these data can only be used for intersport or population comparisons. For ease of comparison, all values have been age adjusted to 30 years, the approximate mean age of all competitors. These values are shown in tables 2-6, Appendix B, for each component in each sport while Figure 10 shows the relative contribution of each to the overall ranking for each sport. Equivalent data for the CF POP are shown for comparison.

From Figure 10 it is evident that, for the three highest ranking sports, all components contribute approximately equally with the notable exception of strength in marathon running. At the low end of the rank order several inequalities are apparent. Strength is apparently very important to bowlers while making a negligible contribution to the fitness of curlers. On the other hand, flexibility is relatively important to curlers. It is a matter for speculation whether these differences are the result of participation in a particular sport or represent a type of natural selection referred to above.

The relatively low position of the CF POP in the rank order suggests that all sports participants except bowlers are deriving a benefit from their regular physical activity relative to the reference group. The relative importance of the aerobic power component to the reference group is probably a reflection of the CF emphasis on aerobic training and testing in effect at the time of these measurements. With respect to overall activity levels between sports, it is suggested that the rank order shown in Figure 10 illustrates the relative duration and intensity of physical effort for each sport. Certainly, bowling requires very little physical effort compared with marathon running.

Table 11. Present Sport Ranking vs Conrad's Activity Ranking

Rank	Present Study Sport	Conrad's Study Activity
1	Volleyball	Jogging
2	Marathon	Bicycling
3	Hockey	Skating & Swimming
4	Broomball	Racquet sports
5	Badminton	Skiing activities
6	Softball	Basketball
7	Curling	Softball
8	Bowling	Bowling

The only other published rank order of recreational physical activities is that of Conrad (1). Table 11 shows a comparison of the ranking reported here with that of Conrad. There is a general agreement with those activities requiring continuous or frequent bouts of physical activity being rated highly and bowling being the least effective on both scales.

For the purposes of intersport comparison, age variations between sports were removed by adjusting all values to a mean age of 30 years. However, consideration of the effect of training and preparation for each sport on the expected age-related decline in performance can only be examined by comparing values at each age. Figures 1-8 compare the age-related performance of all male sports participants with the CF POP. It is apparent that the sports participants show higher values in nearly all measures at all ages and that the rate of decline with age is similar for both groups.

While this picture is generally true for the sports separately, there are some exceptions. For example, forward flexibility is reported to decline with age in a normal population (7,11,12,13) but no age

effect is evident for any of the sports under study here except marathon running. Hand grip strength remained relatively constant for the sport groups through this age range (17-55) but leg strength declined with age except within hockey and volleyball. Again, this may be a selection artifact, in that only those who can maintain a certain level of performance regardless of age will survive to the championship competitions.

Although body composition is not always considered to be a component of physical fitness, there is frequently a close relationship in that percent body fat tends to be inversely related to activity levels (7,11, 14,15). In this study, percent fat was estimated from the combined thickness of three skinfolds (11) and expressed in terms of leanness. Thus, a lower skinfold thickness value would appear as a higher value of leaness indicating a greater muscle mass. Inspection of Figure 10 reveals a wide variation in the leanness contribution to overall rank with bowlers showing the least and marathon runners the greatest leanness, a finding in keeping with the activity levels for the sports. The CF POP is, by comparison, less lean than all groups except bowlers.

The discussion to this point has concentrated on the male participants for two reasons; there is no reference population of females and only three sports with female participants were available for study. Inspection of Figure 11 reveals a situation similar to Figure 10 for the males. Volleyball is ranked the highest by a wide margin with approximately equal contributions of all components. Several inequalities are apparent for both curling and softball. The reasons for this are not immediately apparent and probably reflect some combination of self-selection and opportunity for sports participation.

CONCLUSIONS

Within the limitations discussed above, the data reported in this study appear to support the following conclusions:

1. The male sports population, all sports included, demonstrate a higher level of physical fitness than the CF POP.

2. Using the procedures described in this report, sports activities can be ranked by measuring the physical fitness of the competitors. When this is done, there is a gradation from bowling (lowest level) to volleyball (highest level).

3. There is an inverse relationship between level of measured physical fitness and body composition as assessed by skinfolds.

4. All of the five measured components of physical fitness contribute approximately equally to the overall ranking for the highest rated sports. The most striking inequalities occur in the two lowest ranked sports (bowling and curling).

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APPENDIX A

Details of Test Protocols

Aerobic Power

Measurement Procedure: A step test was used to evaluate the individual's maximum aerobic power.

1. Three heart-rate monitoring electrodes were placed on the subject's chest.

2. A seated, resting heart rate was taken prior to stepping. The step test began if there were no apparent abnormalities in the resting trace and the rate did not exceed 95 beats per minute.

3. If a pre-exercise heart rate was above 95 beats per minute, the subject was asked to relax until the heart rate had decreased.

4. The step height for males was 40 cm; for females, 33 cm.

5. One, two or three, four-minute step test sequences were performed consecutively, with a one-minute rest between tests and with the rate of ascent increasing from 18 to 24 to 30 cycles per minute.

6. The heart rate was recorded during the last 15 seconds of each stepping period. A heart rate in excess of 140 beats/min signalled the end of the test.

7. The oxygen cost of the stepping activity was determined using the equations of Nagel, Balke and Naughton (16). Once the oxygen cost of the activity was determined, the maximum oxygen uptake was predicted using Shephard's formula (17).

APPENDIX A

Strength

Upper Body Stength

Measurement Procedure: A hand grip dynamometer was used to evaluate both right and left hand grip strength.

1. The dynamometer was adjusted so that the thumb touched or overlapped the first finger.

2. The pointer was set to zero and the subject squeezed the dynamometer as hard as possible, keeping the arm and hand away from the side of the body.

3. The score was recorded to the nearest kilogram.

4. The other hand was tested similarly.

5. Trials were repeated for each hand and the highest value recorded.

Lower Body Strength

Measurement Procedure: A vertical jump test was used to evaluate the strength and power of the legs.

1. The subject stood flat-footed facing a wall and reached as high as possible over his head and marked this height with chalk.

2. He moved to a comfortable position away from the wall with either side to the wall and prepared to jump.

3. With the chalk held in the hand closest to the wall, the subject jumped as high as possible and marked the wall at the maximum height.

4. Two practice jumps and three trials were allowed.

5. The distance between the standing height mark and the maximum jump height marked was recorded to the nearest cm.

APPENDIX A

Muscular Endurance

Measurement Procedure: Pushups and situps were used to determine the individual's muscular endurance.

1. Situps were performed first followed by pushups with a 60 second pause between.

2. Each test lasted 60 seconds for males; 30 seconds for females.

3. The number completed within the time limit was recorded.

4. Situps were performed from a flexed knee position with the feet held flat on the floor. Hands were placed behind the head. From the lying position, the subject sat up and touched both elbows to his knees.

5. A complete cycle was from supine position to supine position.

6. Pushups were performed from a front-lying position with the hands at the side of the chest. The body was raised by extending the arms completely while keeping the body in a straight line.

7. Females performed modified pushups (knees on floor, lower legs bent).

8. A complete cycle was from front-lying position to front-lying position.

Flexibility

Measurement Procedure: The sit and reach and the back extension tests were used to determine the flexibility of the individual's trunk.

Sit and Reach

1. The shoeless subject sat on the floor with the legs straight and the feet about 4 inches apart.

2. The soles of the feet were placed against a vertical support. The arms were extended forward and the legs were kept straight.

3. The individual then bent as far forward as possible with arms extended and held this position for 2 seconds.

4. The furthest point reached by the fingers was recorded in cm. One practice attempt and two trials were made.

Back Extension

1. The subject lay face down on the floor and placed his hands (palms down) beside the body.

2. The legs and hips were firmly held to the floor, so that the arch was restricted to the thoracic region.

3. The chin was raised as far off the floor as possible and the vertical distance from the chin to the floor was measured, to the nearest cm.

4. The greatest vertical distance was recorded. One practice attempt and two trials were made.

APPENDIX A

Leaness

Measurement Procedure:

1. Harpenden Skinfold calipers were used to measure the subcutaneous body fat at three sites recommended by the International Biological Program (11):

Tricep - midline on the back of the arm, halfway between the elbow and shoulder;
Subscapular - below the lower angle of the scapula;
Suprailiac - midline of body side, above iliac crest.

2. All skinfolds were taken while the subject was in a relaxed posture and the skinfold was picked up following the natural line of the underlying tissue.

3. Duplicate measurements were taken at each site. If the readings differed by more than 1 mm a third reading was taken. The average of the two closest in agreement was used.

4. The sum of the three skinfolds was used as the leaness indicator.

APPENDIX B

Details of Performance Data Used for Rank Ordering Sports

Tables 2 through 6: Mean Performance Values Corrected to Age 30.

Tables 7 and 8: Rank Order of Sports Within the Fitness Components.

Tables 9 and 10: Class Frequency Tables - Male and Female.

APPENDIX B

Table 2. Aerobic Power Adjusted to Age 30

Mean Value ± SE

Male Sports	VO_2max(ml/(kg*min))
Badminton	40.3 ± 0.9
Bowling	34.1 ± 1.3
Broomball	43.1 ± 0.8
Curling	35.2 ± 1.6
Hockey	45.0 ± 0.9
Marathon	57.4 ± 1.8
Softball	39.9 ± 0.9
Volleyball	42.5 ± 1.1
CF POP	37.5 ± 0.8
Female Sports	
Curling	33.1 ± 1.2
Softball	37.5 ± 1.3
Volleyball	38.7 ± 2.4
CFAO 50-1 Requirement (Category 4)	
Male	41
Female	35.5

APPENDIX B

Table 3. Strength Adjusted to Age 30

Mean Value ± SE

Male Sports	Right Grip (kg)	Left Grip (kg)	Vertical Jump (cm)
Badminton	52.5 ± 1.5	50.2 ± 1.4	55.4 ± 1.4
Bowling	53.5 ± 2.6	49.2 ± 2.1	50.9 ± 2.0
Broomball	57.3 ± 0.7	54.9 ± 0.7	52.3 ± 0.7
Curling	48.1 ± 2.1	43.3 ± 1.8	46.9 ± 2.3
Hockey	58.1 ± 0.9	56.2 ± 0.9	49.3 ± 0.9
Marathon	52.9 ± 2.2	48.5 ± 1.9	49.1 ± 1.8
Softball	55.2 ± 1.0	52.2 ± 1.1	51.5 ± 0.9
Volleyball	58.0 ± 1.1	54.7 ± 1.7	61.6 ± 1.0
CF POP	52.6 ± 0.9	50.1 ± 0.8	46.3 ± 0.9
Female Sports			
Curling	39.3 ± 1.9	36.8 ± 1.9	36.8 ± 1.6
Softball	36.5 ± 1.1	34.0 ± 1.3	37.0 ± 1.2
Volleyball	38.9 ± 1.4	36.8 ± 1.3	43.0 ± 1.3

APPENDIX B

Table 4. Muscular Endurance Adjusted to Age 30

	Mean Value ± SE	
Male Sports	Situps Completed/min	Pushups Completed/min
Badminton	42.5 ± 1.4	32.0 ± 2.2
Bowling	32.3 ± 2.5	25.6 ± 2.2
Broomball	37.7 ± 0.9	30.1 ± 1.3
Curling	34.7 ± 2.0	26.2 ± 2.2
Hockey	37.9 ± 1.1	39.4 ± 1.7
Marathon	44.8 ± 2.0	34.0 ± 2.3
Softball	39.9 ± 1.2	26.1 ± 1.3
Volleyball	46.6 ± 1.2	33.4 ± 1.4
CF POP	35.5 ± 0.8	31.6 ± 1.0
Female Sports	Number of Completions in Thirty Seconds	
Curling	17.3 ± 1.1	18.6 ± 1.1
Softball	23.5 ± 1.0	27.1 ± 1.4
Volleyball	24.4 ± 1.3	26.8 ± 2.0
CFAO 50-1 Requirement (male)	31	28

APPENDIX B

Table 5. Flexibility Adjusted to Age 30

Mean Value ± SE

Male Sports	Sit and Reach (cm)	Back Extension (cm)
Badminton	11.7 ± 1.4	40.0 ± 1.5
Bowling	6.9 ± 2.5	44.2 ± 2.4
Broomball	12.1 ± 0.8	43.6 ± 0.9
Curling	8.3 ± 1.5	45.7 ± 4.0
Hockey	12.6 ± 0.9	43.5 ± 1.1
Marathon	11.3 ± 2.2	51.3 ± 2.2
Softball	5.8 ± 0.9	49.1 ± 1.1
Volleyball	12.4 ± 1.0	57.2 ± 1.2
CF POP	5.2 ± 0.9	46.8 ± 0.8
Female Sports		
Curling	12.5 ± 2.2	49.4 ± 2.2
Softball	8.6 ± 1.5	46.7 ± 0.9
Volleyball	17.1 ± 0.7	54.6 ± 1.2

APPENDIX B

Table 6. Body Composition Adjusted to Age 30

Mean Value ± SE

Male Sports	Skinfolds (sum of 3) (mm)
Badminton	35.1 ± 2.3
Bowling	51.0 ± 2.9
Broomball	37.8 ± 1.5
Curling	40.1 ± 3.5
Hockey	38.4 ± 1.5
Marathon	23.8 ± 1.4
Softball	41.5 ± 1.8
Volleyball	34.1 ± 1.9
CF POP	47.8 ± 1.8
Female Sports	
Curling	48.9 ± 2.6
Softball	50.8 ± 3.5
Volleyball	44.2 ± 5.3

APPENDIX B

Table 7. Aerobic Power - Intersport Rank

Male Sports	Rank
Badminton	5
Bowling	1
Broomball	7
Curling	2
Hockey	8
Marathon	9
Softball	4
Volleyball	6
CF POP	3
Female Sports	
Curling	1
Softball	2
Volleyball	3

APPENDIX B

Table 8. Strength - Intersport Ranking
Illustrating method used when more than one test measurement is available.

Male Sports	right grip	left grip	vertical jump	Combined value	rank
Badminton	2	5	8	15	5
Bowling	5	3	5	13	4
Broomball	7	8	7	22	7.5
Curling	1	1	2	4	1
Hockey	9	9	4	22	7.5
Marathon	4	2	3	9	3
Softball	6	6	6	18	6
Volleyball	8	7	9	24	9
CF POP	3	4	1	8	2
Female Sports					
Curling	3	2.5	1	6.5	2
Softball	1	1	2	4	1
Volleyball	2	2.5	3	7.5	3

APPENDIX B

Table 9. Class Frequency for Male Sports and CF POP

	* BADM	BOWL	BRBALL	CURL	HOCK	MARA	S'BALL	V'BALL	CF POP
1.0		MEB		S					
1.5									
2.0	F	F		M					SBF
2.5				E					E
3.0						S	B		M
3.5									
4.0		S	E	B			M		
4.5				F			F		
5.0	MS				B		E		
5.5									
6.0	E		FB				S	M	
6.5									
7.0	B		M		EF				
7.5			S		S				
8.0					M	F		B	
8.5						E		E	
9.0						MB		SF	
	25	9	30.5	14	34.5	37.5	22.5	40.5	11.5

* BADM = Badminton BOWL = Bowling BRBALL = Broomball

CURL = Curling HOCK = Hockey MARA = Marathon Running

S'BALL = Softball V'BALL = Volleyball CF POP = Reference Population

Legend:

M = Aerobic Power S = Strength E = Muscular Endurance

F = Flexibility B = Leanness

APPENDIX B

Table 10. Class Frequency for Female Sports

	CURLING	SOFTBALL	VOLLEYBALL
1.0	ME	SFB	
1.5			
2.0	FBS	M	
2.5		E	E
3.0			MSFB
	8	7.5	14.5

Legend:

M = Aerobic Power S = Strength E = Muscular Endurance

F = Flexibility B = Leanness

FIGURES

Figure 1. Aerobic Power vs Age for a reference male Canadian Forces population and for the male competitors at the Canadian Forces National Championships held during 1979-1980

Figure 2. Right Grip Strength vs Age for a reference male Canadian Forces population and for the male competitors at the Canadian Forces National Championships held during 1979-1980.

Figure 3. Left Grip Strength vs Age for a reference male Canadian Forces population and for the male competitors at the Canadian Forces National Championships held during 1979-1980.

Figure 4. Vertical Jump Height vs Age for a reference male Canadian Forces population and for the male competitors at the Canadian Forces National Championships held during 1979-1980.

Figure 5. Situps vs Age for a reference male Canadian Forces population and for the male competitors at the Canadian Forces National Championships held during 1979-1980.

Figure 6. Pushups vs Age for a reference male Canadian Forces population and for the male competitors at the Canadian Forces National Championships held during 1979-1980.

Figure 7. Sit and Reach vs Age for a reference male Canadian Forces population and for the male competitors at the Canadian Forces National Championships held during 1979-1980.

Figure 8. Back Extension vs Age for a reference male Canadian Forces population and for the male competitors at the Canadian Forces National Championships held during 1979-1980.

Figure 9. Sum of Three Skinfold Thicknesses vs Age for a reference male Forces population and for the male competitors at the Canadian Forces National Championships held during 1979-1980.

Figure 10. The Rank Order and Relative Physical Fitness Value of the male Sports played in the Canadian Forces as determined from the physical fitness of the competitors.
BOWL=Bowling CF POP=Sample Population CURL=Curling
S'BALL=Softball BADM=Badminton BRBALL=Broomball
HOCK=Hockey MARA= Marathon Running V'BALL=Volleyball

Figure 11. The Rank Order and Relative Physical Fitness Value of the female Sports played in the Canadian Forces as determined from the physical fitness of the competitors.

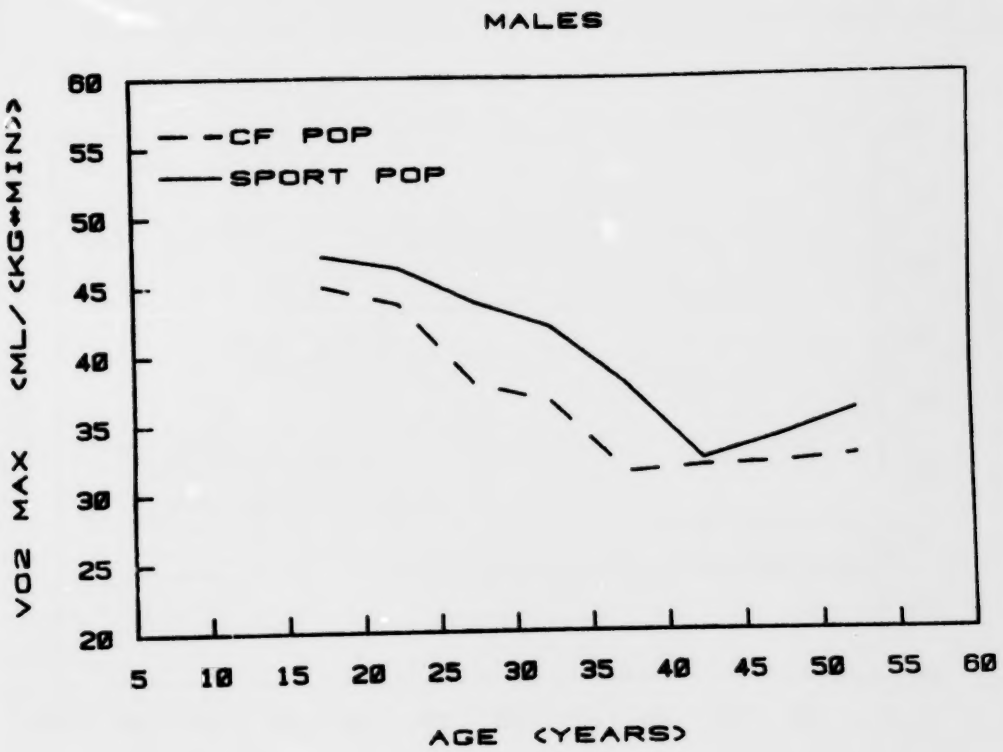

Figure 1. Aerobic Power vs Age for a reference male Canadian Forces population and for the male competitors at the Canadian Forces National Championships held during 1979-1980 ($P < .05$).

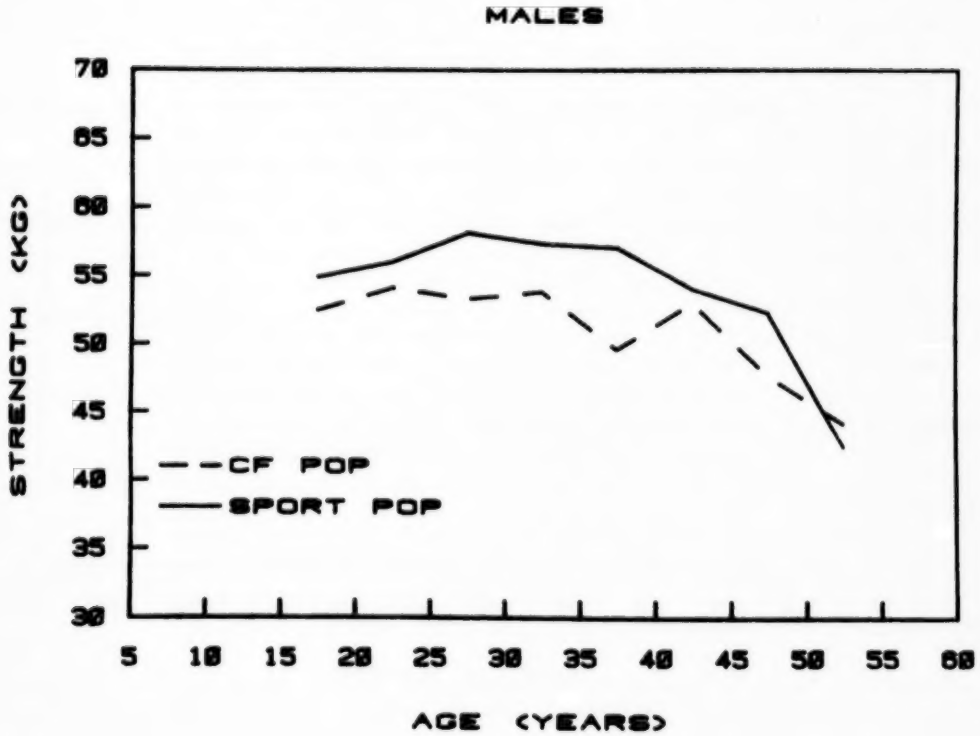

Figure 2. Right Grip Strength vs Age for a reference male Canadian Forces population and for the male competitors at the Canadian Forces National Championships held during 1979-1980 ($P<.05$).

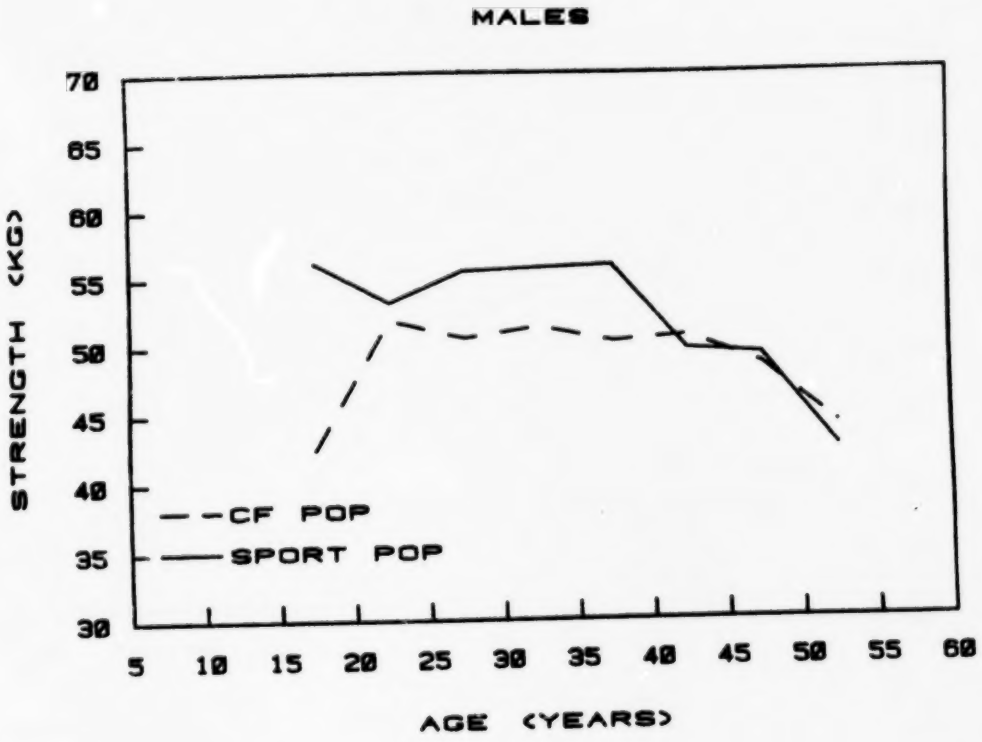

Figure 3. Left Grip Strength vs Age for a reference male Canadian Forces population and for the male competitors at the Canadian Forces National Championships held during 1979-1980 ($P<.05$).

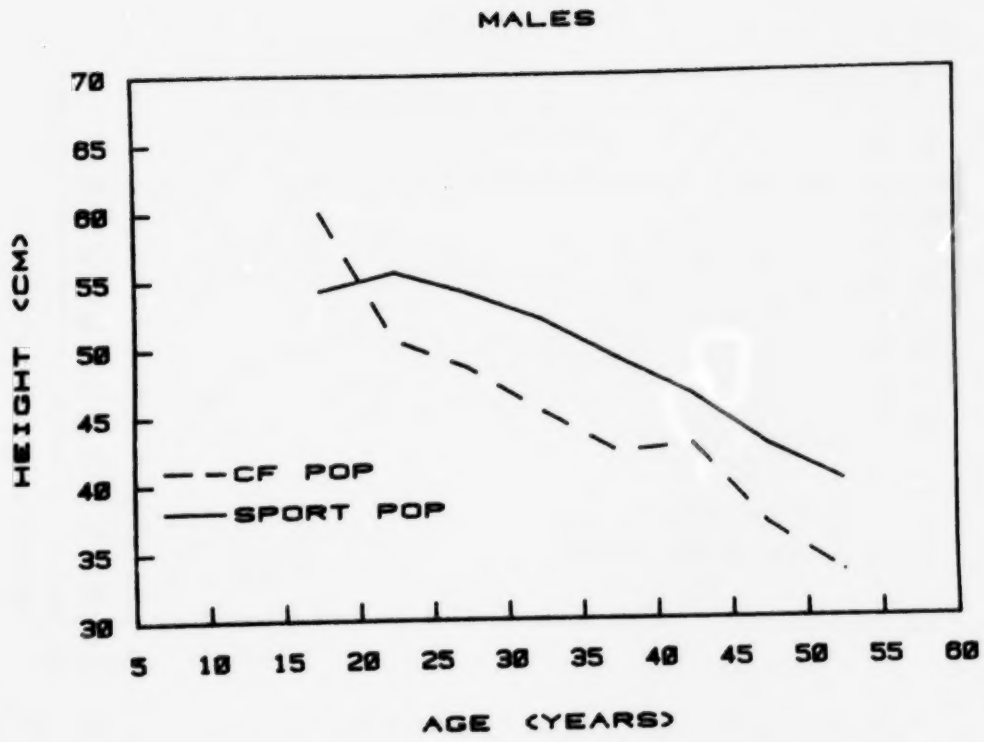

Figure 4. Vertical Jump Height vs Age for a reference male Canadian Forces population and for the male competitors at the Canadian Forces National Championships held during 1979-1980 ($P<.05$).

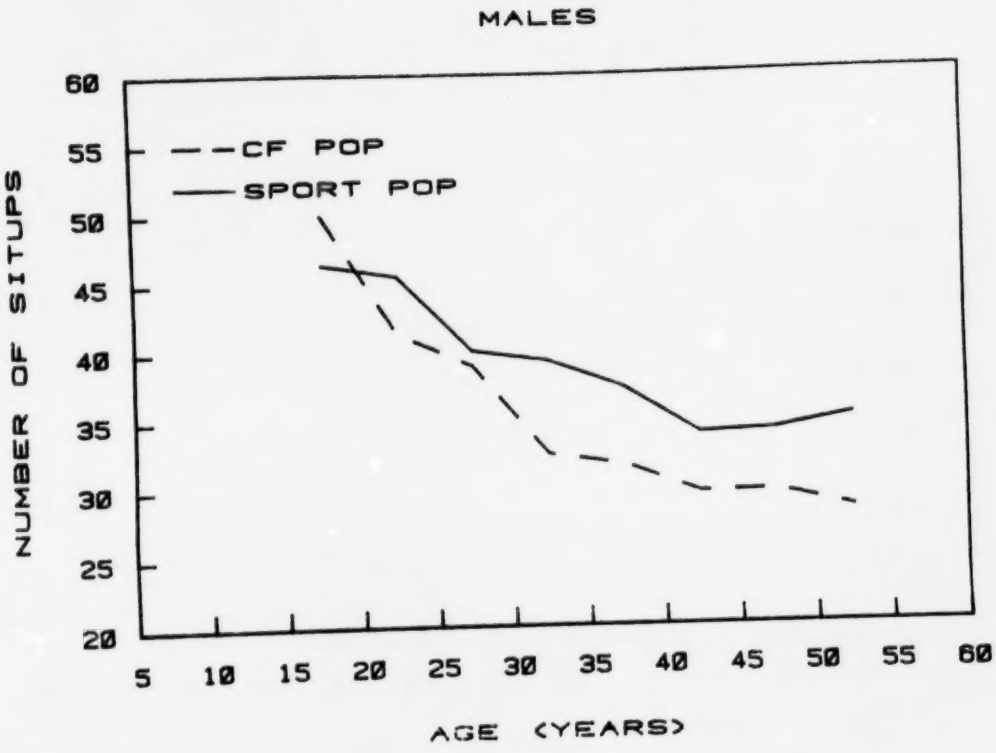

Figure 5. Situps vs Age for a reference male Canadian Forces population and for the male competitors at the Canadian Forces National Championships held during 1979-1980 ($P<.05$).

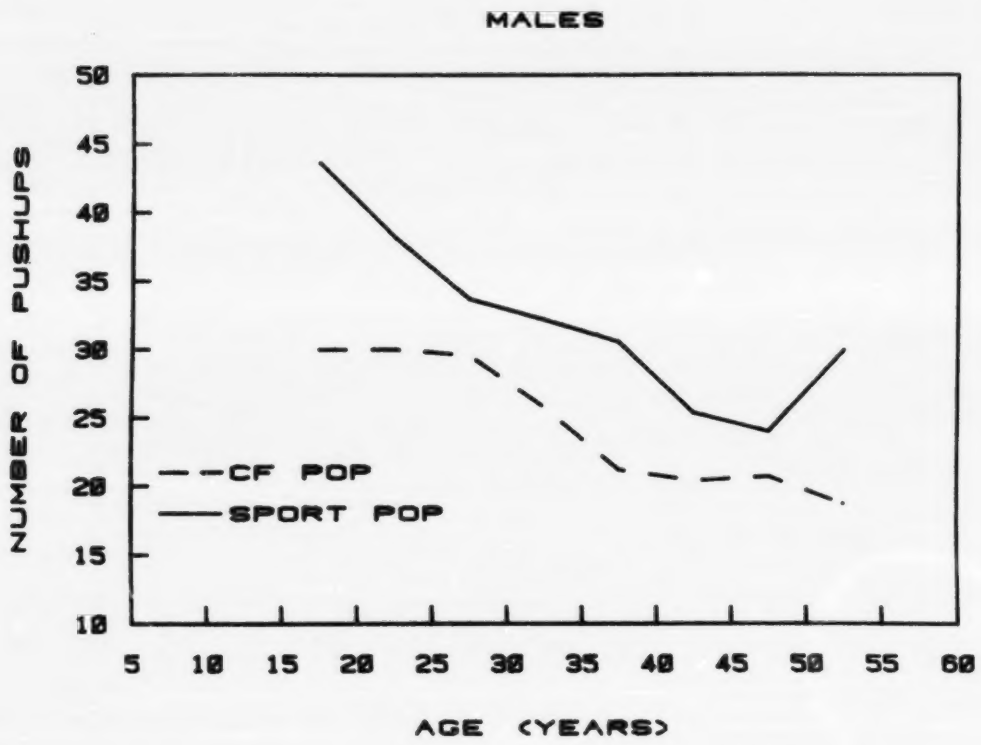

Figure 6. Pushups vs Age for a reference male Canadian Forces population and for the male competitors at the Canadian Forces National Championships held during 1979-1980 ($P<.05$).

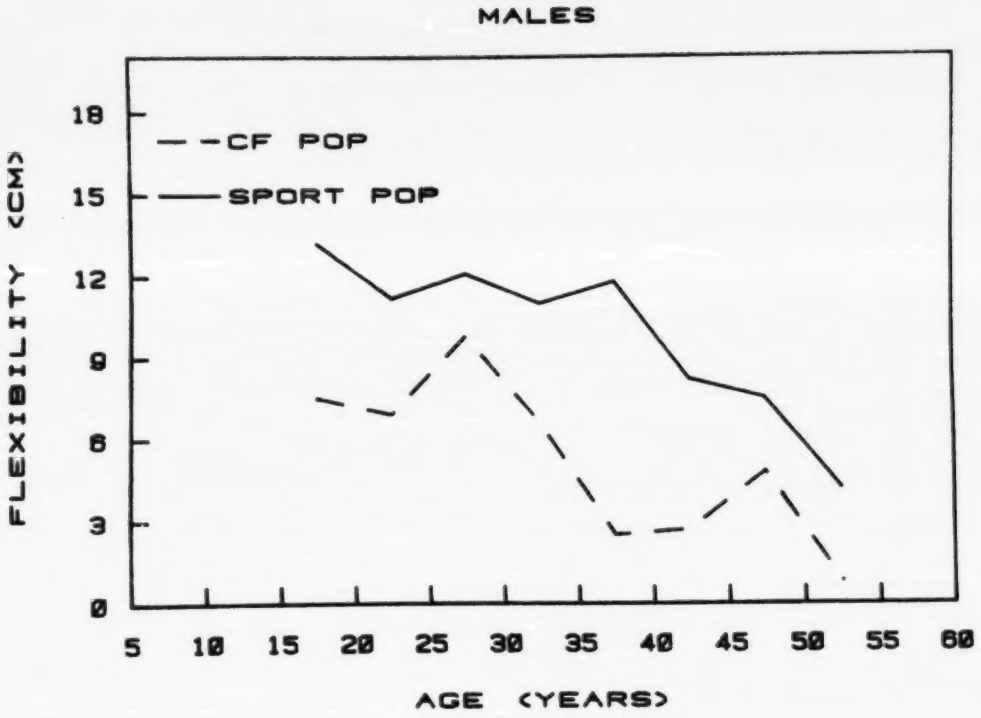

Figure 7. Sit and Reach vs Age for a reference male Canadian Forces population and for the male competitors at the Canadian Forces National Championships held during 1979-1980 ($P<.05$).

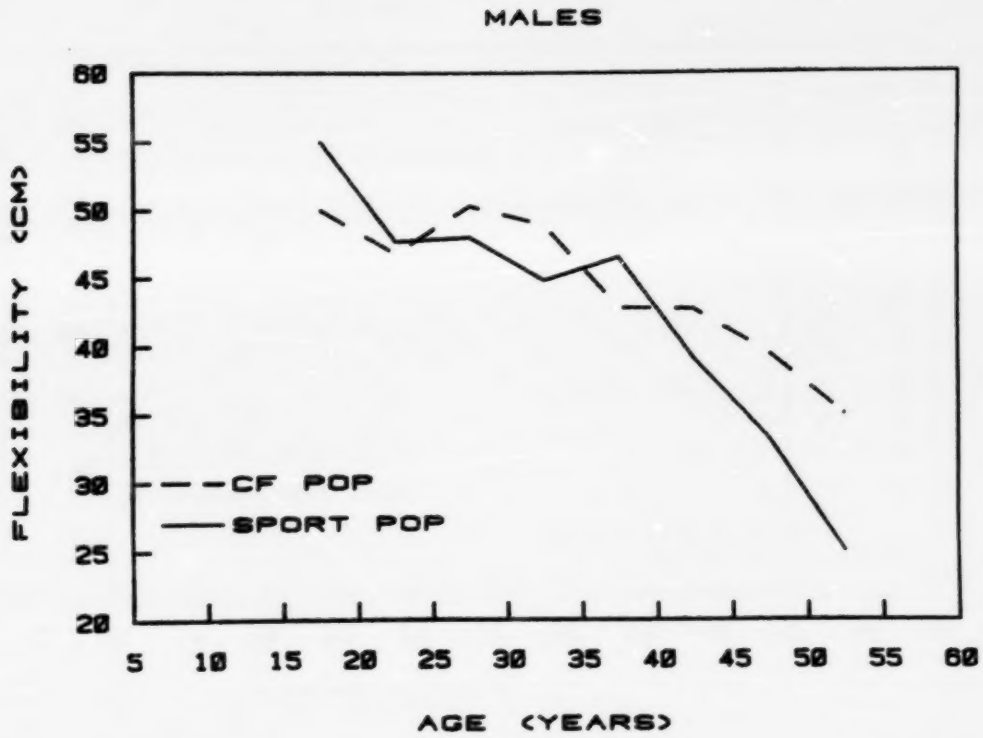

Figure 8. Back Extension vs Age for a reference male Canadian Forces population and for the male competitors at the Canadian Forces National Championships held during 1979-1980 (NS).

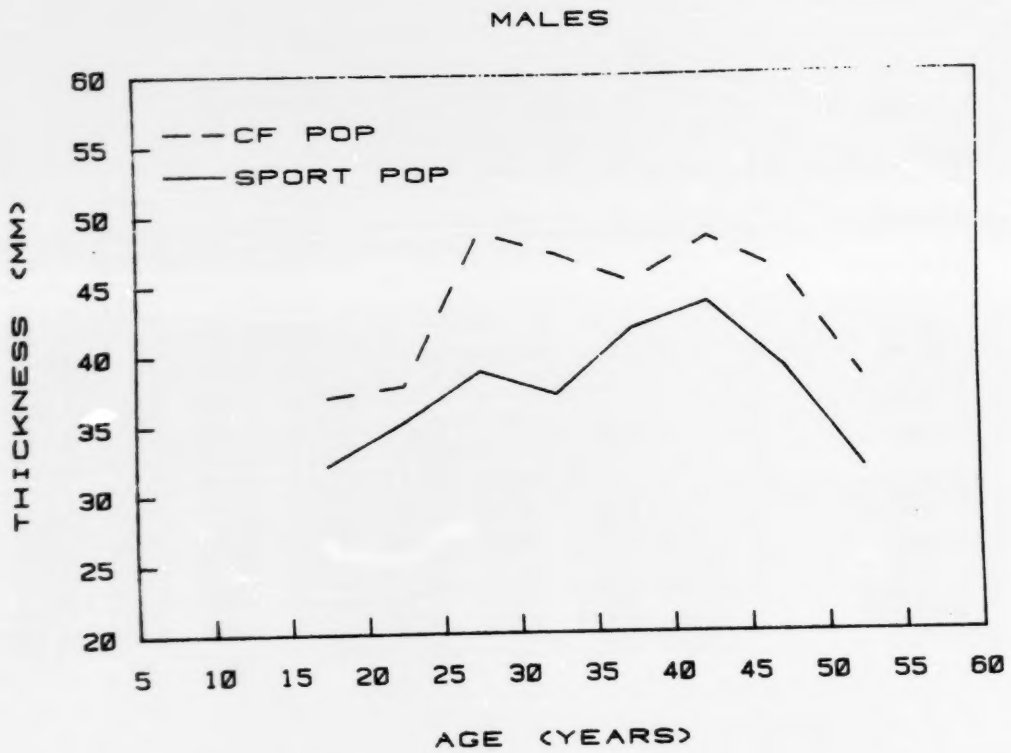

Figure 9. Sum of Three Skinfold Thicknesses vs Age for a reference male Canadian Forces population and for the male competitors at the Canadian Forces National Championships held during 1979-1980 ($P<.05$).

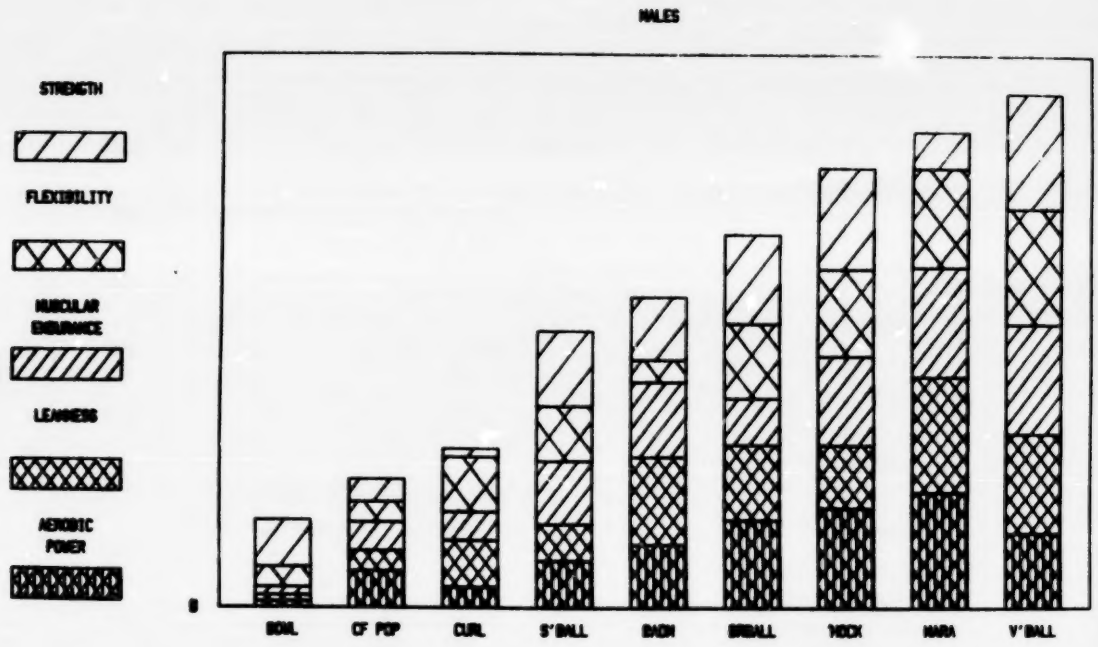

Figure 10. The Rank Order and Relative Physical Fitness Value of the male Sports played in the Canadian Forces as determined from the physical fitness of the competitors ($P<.001$).
BOWL = Bowling CF POP = Reference Population
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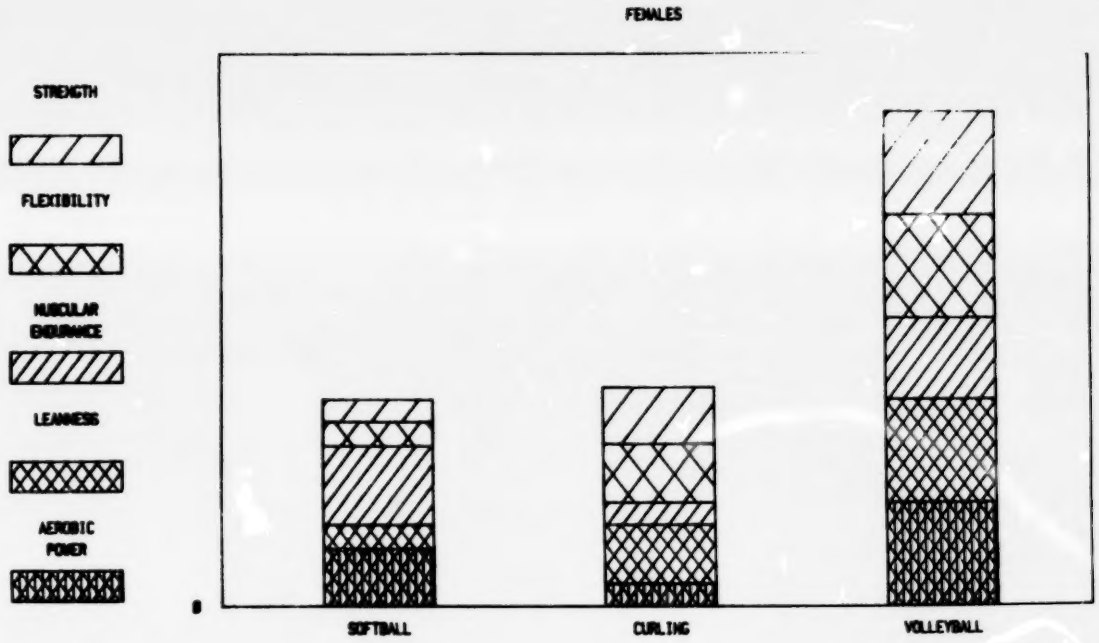

Figure 11. The Rank Order and Relative Physical Fitness Value of the female Sports played in the Canadian Forces as determined from the physical fitness of the competitors ($P<.001$).

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